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ATTACHMENT D

ADVANCED TECHNOLOGY MICROWAVE SOUNDER (ATMS)

MISSION ASSURANCE REQUIREMENTS (MAR)

June 23, 2000

GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND

INTEGRATED PROGRAM OFFICE
SILVER SPRING, MARYLAND

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Mission Assurance Requirements (MAR)

for the NPP/NPOESS Programs

ATMS Instrument

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NOTE: After revising the document, file this sheet in document preceding table of contents.

TABLE OF CONTENTS

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1.0 OVERALL REQUIREMENTS

1. 1 DESCRIPTION OF OVERALL REQUIREMENTS

The developer shall establish and conduct an organized program which will demonstrate that the instrument design meets all functional requirements within specified margins. This shall be accomplished by conducting analyses, reviews, tests, and inspections.

The developer is required to implement and maintain a performance assurance program that encompasses all of the developer's flight and ground equipment and software including flight spares and associated Government furnished flight and ground equipment. The program applies to all work accomplished by the developer (also termed "contractor") and the developer's subcontractors and suppliers of deliverable hardware and support.

1. 2 MANAGEMENT OF THE ASSURANCE PROGRAM

The developer shall implement a system for effective management control and audit of the assurance program. The developer shall assign responsibility and authority for managing the assurance activities to individuals having unimpeded access to higher management. The developer shall ensure that developer assurance personnel have timely unimpeded access to products in order to perform pertinent assurance functions and that these personnel participate as appropriate in test planning activities and review activities.

1. 3 SURVEILLANCE OF THE DEVELOPER

The work activities, operations, and documentation of the developer, subcontractors, and suppliers are subject to evaluation, review, survey, and inspection by Government-designated representatives from the GSFC project office, the cognizant Government Inspection Agency (GIA), or an independent assurance contractor (IAC) at the developer, subcontractor or supplier's facilities. GSFC will delegate comprehensive and specific in-plant responsibilities and authority to those agencies in a letter of delegation (LOD) or through the GSFC contract with the IAC.

The developer shall provide Government representative(s) with documents, records, equipment, and working areas within his facilities that are required by the Government representative(s) to perform his overview activities.

Where developer source inspection is used, the developer shall provide a list of duties, responsibilities, and authorities of his at-source quality assurance (QA) personnel to the designated Government quality representative at the developer's facility. When both developer and Government source inspection personnel are used at any developer's facility, the listing shall also be provided to the Government source representative at that facility upon issuance of the procurement. At no time shall Government source inspection be used in lieu of developer's source inspection.

1. 4 GENERAL PROCUREMENT REQUIREMENTS

1.4.1 SELECTION OF SOURCES

When the developer selects procurement sources, assurance personnel shall be assigned to participate in the selection. Performance history, receiving inspection and test results, the supplier rating system, and pre-award survey results shall be used to assess the capability of each potential procurement source in producing reliable products.

1.4.2 REQUIREMENTS ON SUBCONTRACTORS AND SUPPLIERS

The developer shall ensure that procurement documents impose the applicable requirements of this contract on subcontractors and other suppliers. The subcontractors and other suppliers shall in turn impose the requirements on their procurement sources.

1. 5 AUDITS

The developer shall conduct audits of his assurance activities and those of his subcontractors and suppliers to ensure compliance with all appropriate provisions of the MAR and the provisions of other procurement documents. The audit program shall include provisions for the examination of operations and documentation as well as the examination of products and materials.

1. 6 APPLICABLE DOCUMENTS

To the extent referenced herein, applicable portions of the documents listed in Section 13, including the Sensor Requirements Document (SRD) "Common Section", form a part of this document. The revision levels in effect at the time of the issuance of the Request for Proposal form a part of this document. Where any referenced document conflicts with the requirements of this document, this document shall take precedence.

1. 7 ACRONYMS

Section 14 defines acronyms as applied in this document.

2.0 SYSTEM SAFETY REQUIREMENTS

2. 1 GENERAL REQUIREMENTS

The developer shall plan and conduct a system safety program for the instrument and developer-supplied ground support equipment (GSE) that accomplishes the following:

a. Provides for the identification and control of hazards to personnel, facilities, support equipment, and flight systems during all stages of project development and integration. The program shall also consider hazards in the flight hardware, software, associated equipment and potential malfunctions in instrument GSE that may affect the spacecraft or the launch vehicle;

b. Satisfies the applicable guidelines, constraints, and requirements stated in the latest version of the EWR 127-1, Eastern and Western Range Safety Requirements;

c. Interfaces effectively with the industrial safety requirements of the contract and the developer's existing safety program.

2. 2 SYSTEM SAFETY PROGRAM PLAN (SSPP)

In accordance with Chapter 1 of EWR 127-1 and appendices, the developer shall prepare and submit a System Safety Program Plan (SSPP) to the NASA Project Office. The developer documents referenced therein shall be submitted with the plan.

The SSPP shall describe the safety program requirements, the plan for implementing them, and shall reference the detailed procedures the developer will invoke to ensure the identification and control of hazards to personnel and hardware during fabrication, tests, transportation, ground activities, launch, and mission operations.

2. 3 STRUCTURAL INTEGRITY AND FRACTURE CONTROL

Verification of the structural integrity of the instrument is required. When Engineering Development Unit (EDU) and proto-flight testing to verify the structural design is conducted, no further verification of fracture control is required. Where such testing is not required, or for follow-on hardware (which is not normally subjected to EDU and proto-flight testing), the developer shall verify structural integrity by subjecting the instrument hardware to an appropriate series of proof loads tests to limit levels.

2. 4 ANALYSES

2.4.1 INSTRUMENT HAZARD ANALYSES

Early in the design phase, the developer shall perform hazard analyses to identify any hazard(s) originating from the instrument or developer provided GSE. If necessary, the analyses shall be performed at the component and instrument levels and shall identify all

hazards affecting personnel, ELV hardware, the Observatory, observatory GSE, instrument GSE, other payload instruments, or the developer's instrument. The analyses shall be conducted to the requirements of Chapters 3 and 6 of the EWR 127-1 and shall provide all information necessary to complete the Missile System Pre-Launch Safety Package (MSPSP).

Throughout the instrument development effort, the developer shall take measures to eliminate or to minimize the effects of each hazard identified. The hazard analyses shall be updated as the hardware progresses through the stages of design, fabrication, test, transportation, integration, and launch. The hazard analyses shall be available at the developer's facility. Payload Hazard Reports shall document the causes, controls, verification methods, and status of verification for each hazard and shall be included as part of the MSPSP (see section 2.9). The Payload Hazard Reports shall reflect status at the phase of the safety review program for which the current MSPSP is being submitted.

Summaries of the Payload Hazard Reports and the status of hazard control efforts shall be reported at design and readiness reviews (see section 2.7).

2.4.2 OPERATIONS HAZARD ANALYSES (OHA)

When the use of a facility or when the performance of an activity could result in subjecting the instrument or personnel to catastrophic hazards, an Operations Hazard Analysis (OHA) shall be performed to identify the hazards and document the requirements for either eliminating or adequately controlling each hazard. Operations that may require analyses include handling, transportation, functional tests, and environmental test. Summary Results of each OHA performed shall be included in the MSPSP.

2. 5 HAZARD CONTROL VERIFICATION

Verification of the control of all hazards shall be accomplished by test, analysis, inspection, similarity to previously qualified hardware, or any combination of these activities. Reports of such verifications performed by the developer shall be incorporated in the Payload Hazard Reports (see section 2.4.1).

2. 6 PROCEDURE APPROVAL

The developer's safety engineer shall review and approve all procedures affecting flight hardware and developer provided GSE for conformance with range requirements. Hazardous operations shall be identified and procedures to control them shall be developed and implemented.

2. 7 REVIEWS

The systems safety status shall be examined at the GSFC OSSMA review as well as at other applicable Air Force Space Command Western Range (WR) safety reviews. The developer shall submit the current safety data at the time of the GSFC Critical Design Review (CDR), Delta Critical Design Review (ΔCDR), and Pre-Ship Review (PSR) and

all flight readiness reviews. The Western Range (WR) reviews are required as part of EWR 127-1 at the following instrument milestones:

Phase 1 - Around the time of GSFC CDR;

Phase 2 - Around the time of GSFC ΔCDR;

Phase 3 - 90 days prior to shipping the instrument to the spacecraft developer.

The developer shall provide data inputs required by the WR and technical support to the NASA project office for all safety reviews. The developer shall review the systems safety program of subcontractors.

2. 8 NONCOMPLIANCE REQUEST

When a specific safety requirement cannot be met, the developer shall submit a noncompliance request in accordance with Chapter 1 EWR 127-1 appendix 1C. The noncompliance request shall state the requirement that cannot be met, the reason it cannot be met, the proposed method of controlling the additional risk, and the residual risk after application of the additional controls. Each noncompliance request shall address only one hazard and shall be submitted in accordance with the CDRL as soon as it is determined that one is required. The noncompliance shall be addressed at the following review. Range may require 2 weeks to 60 days to process the request.

2. 9 MISSIILE SYSTEM PRE-LAUNCH SAFETY PACKAGE (MSPSP)

The instrument developer shall update and submit to the NASA Project office an MSPSP that complies with the requirements of EWR 127-1 prior to each WR review. The content of the package shall be appropriate to the phase of the program at the time of delivery and shall include the Payload Hazard Reports. The developer shall include with the updated MSPSP, copies of any noncompliance requests that have been generated since the last review. The MSPSP must be approved by the OSSMA prior to submittal to the WR.

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3.0 ASSURANCE REVIEW REQUIREMENTS

3. 1 GENERAL REQUIREMENTS

The instrument developer shall support a series of comprehensive instrument-level and system-level design reviews that are conducted by a GSFC OSSMA Review Team. The reviews shall cover all aspects of flight and ground hardware, software, and operations for which the developer has responsibility. The developer shall also conduct a program of planned, scheduled and documented developer reviews at component and subsystem levels of all hardware and software.

3. 2 GSFC OSSMA REVIEW REQUIREMENTS

For each specified review conducted by the GSFC OSSMA Review Team, the developer shall:

a. Develop and organize material for oral presentation to the GSFC review team. Copies of visual aids and other supporting material that are pertinent to the review shall be submitted per the CDRL;

b. Support splinter review meetings resulting from the major review;

c. Submit written responses to recommendations and action items resulting from the review in accordance with the CDRL.

3. 3 GSFC OSSMA REVIEW PROGRAM

The OSSMA Review Program shall consists of individual reviews of each instrument and its associated systems. Each instrument and its associated subsystems shall have the following series of reviews at the instrument level; these shall include information in sufficient detail to facilitate understanding of the instrument, its functions and operations in accordance with the CDRL. The developer shall also support NASA reviews of the instrument flight software as required by section 11 of this document. The instrument-level reviews are:

- Critical Design Review (CDR). This review shall occur prior to the manufacture of engineering hardware.

- Delta Critical Design Review (ΔCDR). This review shall be conducted to approve the "frozen" design prior to the start of manufacture of flight components. It will emphasize implementations of design as well as test plans for flight systems including the results of engineering model testing.

- Pre-environmental Review (PER). This review shall be conducted prior to the start of environmental testing of the (instrument) EDU, proto-flight or flight

system. The primary purposes of this review are to establish the readiness of the system for test and to evaluate the environmental test plans.

- Pre-shipment Review (PSR). This review shall take place prior to shipment of the instrument to the Observatory for integration, and will concentrate on instrument performance during acceptance testing.

3. 4 SYSTEM SAFETY

System safety shall be an agenda item for each review in paragraph 3.3 and as such shall serve to support the total system safety review program.

3. 5 DEVELOPER REVIEW REQUIREMENTS

The developer shall conduct a program of reviews at the component and subsystem levels of the instrument. The review program shall include the ground support equipment and shipping containers for the instrument. The program shall, as a minimum, consist of a CDR and a ΔCDR at these levels of assembly. In addition, packaging reviews shall be conducted on all electrical, electronic, and electromechanical components in the instrument system.

The developer shall also conduct design reviews of any custom designed microcircuits, including hybrids, as required by paragraph 6.2.2.1.

The CDR and ΔCDR shall evaluate the ability of the component or subsystem concept and design to successfully perform its function under operating and environmental conditions during both testing and flight.

The packaging reviews shall be conducted in accordance with GSFC S-311-98, "Guidelines for Conducting a Packaging Review". In addition to these packaging guidelines, the reviews shall specifically address the following:

a. Placement, mounting, and interconnection of each EEE part or circuit board or substrate;

b. Structural support and thermal accommodation of the boards and substrates and their interconnecting in the component design; and

c. Provisions for protection of the parts and ease of inspection.

Pertinent parts stress analyses and reports of the corresponding component packaging reviews, including the results of associated tests and analyses, shall be included in the CDRs and ΔCDRs for each component.

Developer personnel who are not directly responsible for hardware design shall conduct reviews. The results of the reviews shall be documented and shall be available to NASA upon request.

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4.0 DESIGN VALIDATION REQUIREMENTS

4. 1 GENERAL REQUIREMENTS

An instrument performance verification program documenting the overall verification plan, implementation, and results is required to ensure that the instrument meets the specified mission requirements, and to provide traceability from mission specification requirements to launch and on-orbit capability. The program consists of a series of functional demonstrations, analytical investigations, physical property measurements, inspections and tests that simulate the environments encountered during handling and transportation, pre-launch, launch, and in-orbit. The EDU and proto-flight hardware shall undergo qualification to demonstrate compliance with the verification requirements of this section. In addition, all other hardware (flight, follow-on, and spare) shall undergo acceptance in accordance with the verification requirements of this section.

The Verification Program begins with functional testing of assemblies; it continues through functional and environmental testing supported by appropriate analysis, at the component, subsystem, instrument, and observatory levels of assembly. The program concludes with end-to-end testing of the entire instrument system.

4. 2 DOCUMENTATION REQUIREMENTS

4.2.1 SYSTEM PERFORMANCE VERIFICATION MATRIX

A System Performance Verification Matrix shall be prepared and maintained in accordance with the CDRL, to show each specification requirement, the reference source (to the specific paragraph or line item), the method of compliance, applicable procedure references, results, report reference numbers, etc.

4.2.2 FABRICATION, ASSEMBLY AND TEST FLOW PLAN

As an adjunct to the Performance Verification Matrix, a Fabrication, Assembly and Test Flow Plan (FATFP) shall be prepared in accordance with the CDRL. The FATFP shall include all tests that will be performed at the component, subsystem, and instrument levels. The purpose of the FATFP is to provide a ready reference to the contents of the test program in order to prevent the deletion of a portion thereof without an alternative means of accomplishing the objectives. All flight hardware, spares, prototypes, or engineering units used in the qualification program (when appropriate) shall be included in the FATFP.

4.2.3 PERFORMANCE VERIFICATION PROCEDURES

Performance Verification Procedures shall be prepared in accordance with the CDRL. For each verification test activity conducted at the component, subsystem, and instrument levels, a procedure shall be prepared that describes the configuration of the test article, how each test activity contained in the verification plan and specification will be implemented.

4.2.4 VERIFICATION REPORTS

After each component, subsystem, instrument, verification activity has been completed, a Verification Report shall be completed and submitted in accordance with the CDRL. For each analysis activity, the report shall describe the degree to which the objectives were accomplished, how well the mathematical model was validated by related test data, and other such significant results. In addition, as-run verification procedures and all test and analysis data shall be retained for review.

4. 3 ELECTRICAL FUNCTIONAL TEST REQUIREMENTS

The following paragraphs describe the required electrical functional and performance tests that verify the instrument operation before, during, and after environmental testing. These tests along with all other calibrations, functional/performance tests, measurements, demonstrations, alignments (and alignment verifications), end-to-end tests, simulations, etc., that are part of the overall verification program shall be described in the FATFP.

4.3.1 ELECTRICAL INTERFACE TESTS

Before the integration of a component or subsystem into the next higher hardware assembly, electrical interface tests shall be performed to verify that all interface signals are within acceptable limits of applicable performance specifications. Prior to mating with other hardware, electrical harnessing shall be tested to verify proper characteristics such as routing of electrical signals, impedance, isolation, and overall workmanship.

4.3.2 COMPREHENSIVE PERFORMANCE TESTS

An appropriate comprehensive performance test (CPT) shall be conducted at the instrument level. When environmental testing is performed at a given level of assembly, additional comprehensive performance tests shall be conducted during the hot and cold extremes of the temperature or thermal-vacuum test and at the conclusion of the environmental test sequence, as well as at other times prescribed in the verification procedures.

The comprehensive performance test shall be a detailed demonstration that the hardware and software meet their performance requirements within allowable tolerances. The test shall demonstrate operation of all redundant circuitry and satisfactory performance in all operational modes. The initial CPT shall serve as a baseline against which the results of all later CPTs can be readily compared.

At the instrument level, the comprehensive performance test shall demonstrate that, with the application of known stimuli, the instrument will produce the expected responses. At lower levels of assembly, the test shall demonstrate that, when provided with appropriate inputs, internal performance is satisfactory and outputs are within acceptable limits.

4.3.3 LIMITED PERFORMANCE TESTS

Limited performance tests (LPTs) shall be performed at the instrument level before, during, and after environmental tests, as appropriate, in order to demonstrate that functional capability of the instrument has not been degraded by the tests. The limited tests are also used in cases where comprehensive performance testing is not warranted. In those cases, the LPTs shall become the baseline tests for performance degradation trending. LPTs shall demonstrate that the performance of selected hardware and software functions is within acceptable limits. Specific times when LPTs will be performed shall be prescribed in the FATFP.

4.3.4 ALIVENESS TEST

An aliveness test shall be performed to verify that the instrument and its major components are functioning, and that changes or degradation have not occurred as a result of environmental exposure, handling, transportation or faulty installation. This test shall be performed after major environmental tests, handling and transportation of the instrument, and shall be significantly shorter in duration than a CPT or LPT. Specific times when aliveness tests will be performed shall be prescribed in the FATFP.

4.3.5 PERFORMANCE OPERATING TIME AND FAILURE-FREE PERFORMANCE TESTING

At the conclusion of the performance verification program, the instrument shall have demonstrated failure-free performance testing for at least the last 500 hours of operation. The demonstration may include operating time at the subsystem level of assembly when instrument testing provides insufficient test time to accumulate the trouble-free-operation, or when integration is accomplished at the launch site and the 500-hour demonstration cannot practicably be accomplished at the observatory. Failure-free operation during the thermal-vacuum test exposure is included as part of the demonstration of the trouble-free operation being logged at the hot-dwell and cold-dwell temperatures. Major hardware changes during or after the verification program shall invalidate previous demonstration.

4.3.6 TESTING OF LIMITED-LIFE ELECTRICAL ELEMENTS

A life test program shall be considered for electrical elements that have limited lifetimes as identified in the Limited-Life Items List. The FATFP shall address the life test program, identifying the electrical elements that require such testing, describing the test hardware that will be used, and the test methods that will be employed.

4. 4 STRUCTURAL AND MECHANICAL REQUIREMENTS

The developer shall demonstrate compliance with structural and mechanical requirements through a series of interdependent test and analysis activities. The demonstrations shall verify design and specified factors of safety, ensure spacecraft interface compatibility, acceptable workmanship, and material integrity. In addition, certain activities needed to satisfy the safety requirements may best be accomplished in conjunction with these demonstrations.

When planning the tests and analyses, the developer shall consider all expected environments including those of structural loads, vibro-acoustics, mechanical shock, and pressure profiles. Mass properties and mechanical functioning shall also be verified.

The program outlined below assumes that the design of the instrument is sufficiently modularized to permit realistic environmental exposures at the subsystem level. The developer shall ensure that each subsystem of the instrument (structure, power, command and data handling, etc.) is verified for each of the requirements identified below. In some cases, it may be desirable to satisfy the requirements by test at the instrument or component level of assembly in lieu of testing at the subsystem level.

It is the developer's responsibility to document a meaningful set of activities that best demonstrates compliance with the requirements.

4.4.1 STRUCTURAL LOADS

Verification for the structural loads environment shall be accomplished by a combination of test and analysis. A modal survey shall be performed at the instrument level to verify that the analytic model adequately represents the hardware's dynamic characteristics. The test-verified model shall then be used to predict the maximum expected load for each potentially critical loading condition, including handling and transportation, vibro-acoustic effects during lift-off. The maximum loads resulting from the analysis define the limit loads.

Verification of the design strength of the hardware shall be accomplished as indicated in the SRD "Common Section". If appropriate development tests are performed to verify accuracy of the stress model, and stringent quality control procedures are invoked to ensure conformance of the structure to the design, then strength verification may be accomplished without test by a stress analysis in accordance with the SRD "Common Section".

The use of materials that are susceptible to brittle fracture or stress-corrosion cracking require definition of and strict adherence to appropriate additional procedures to prevent problems. It is emphasized that all structural elements shall be in compliance with applicable safety requirements.

4.4.2 VIBRO-ACOUSTICS

To satisfy the vibro-acoustic requirements, a design verification test program shall be developed which is based on an assessment of the expected mission environments and is in accordance with the SRD "Common Section".

4.4.3 SINUSOIDAL SWEEP VIBRATION VERIFICATION

The instrument shall be subjected to a sine sweep vibration to verify the ability to survive the low-frequency launch environment in accordance with the requirements of the SRD "Common Section". The test also provides a workmanship vibration test for hardware which normally does not respond significantly to the vibro-acoustic environment at frequencies below 100 Hz, such as wiring harnesses and stowed appendages, but can experience significant responses from low-frequency sine transient vibration and any sustained, pogo-like sine vibration. It should be noted that sine sweep test will be performed at the observatory level.

4.4.4 MECHANICAL SHOCK

Both self-induced and externally induced shocks shall be considered in defining the mechanical shock environment. All subsystems shall be exposed to all self-induced shocks by actuation of the shock-producing devices in accordance with the SRD "Common Section".

4.4.5 MECHANICAL FUNCTION

4.4.5.1 Design Verification

A kinematics analysis of all instrument mechanical operations shall be performed in accordance with the SRD "Common Section". The developer shall: (a) ensure that each mechanism can perform satisfactorily and has adequate margins under worst-case conditions; (b) ensure that satisfactory clearances exist for both the stowed and operational configurations as well as during any mechanical operation; and (c) ensure that all mechanical elements are capable of withstanding the worst-case loads that may be encountered.

Instrument verification tests are required to demonstrate that the installation of each mechanical device is correct and that no problems exist that will prevent proper operation of the mechanism during mission life.

4.4.5.2 Life Testing

A life test program shall be implemented for mechanical and electromechanical devices such as compensators and scanners that move repetitively as part of their normal function and whose useful life must be determined in order to verify their adequacy for the mission. The developer shall identify such limited life items and the life testing) in the FATFP. Trend analysis and reporting shall be performed.

For limited life items for which life-testing will not be performed, the rationale for eliminating the test shall be provided along with a description of the analyses that will be done to verify the validity of the rationale.

4.4.5.3 Torque Ratio

The torque ratio requirements are defined in the SRD "Common Section".

4.4.6 MASS PROPERTIES

The mass properties program shall include an analytic assessment of the instrument's ability to comply with the mission requirements, including constraints imposed by the launch vehicle, supplemented as necessary by measurement. The Mass Properties Report shall be prepared and submitted in accordance with the CDRL. During the instrument development, it is required that this data be reported in the monthly reports and discussed at quarterly and design reviews. In addition, a comprehensive alignment program shall be included.

4. 5 ELECTROMAGNETIC COMPATIBILITY (EMC) REQUIREMENTS

The electromagnetic characteristics of hardware shall be designed in accordance with the requirements of the SRD "Common Section" such that:

a. The instrument and its elements shall not generate electromagnetic interference that could adversely affect its own subsystems and components, other instruments, the spacecraft, or the safety and operation of the launch vehicle, or the launch site;

b. The instrument and its subsystems and components shall not be susceptible to emissions that could adversely affect their safety and performance. This applies whether the emissions are self-generated or derive from other sources, or whether they are intentional or unintentional.

4. 6 VACUUM, THERMAL, AND HUMIDITY REQUIREMENTS

In the vacuum, thermal, and humidity areas it shall be demonstrated that:

a. The instrument shall perform satisfactorily in the vacuum and thermal environment of space;

b. The thermal design and the thermal control system shall maintain the affected hardware within the established mission thermal limits;

c. The hardware shall withstand, as necessary, the temperature and humidity conditions of transportation, storage, and ELV launch.

The developer shall demonstrate compliance by conducting a set of tests and analyses that collectively meet the requirements defined in the SRD and the following paragraphs. Tests may require supporting analyses and vice versa.

4.6.1 THERMAL-VACUUM

The thermal-vacuum test shall demonstrate the ability of the instrument to perform satisfactorily in functional modes representative of the mission in vacuum at the nominal mission operating temperatures, at temperatures 10 degrees C beyond the predicted mission extremes, and during temperature transitions. The test shall also demonstrate the ability of the instrument to perform satisfactorily after being exposed to the predicted nonfunctional extremes of the mission, including the 10 degrees C margin. Cold and hot turn-on's shall be demonstrated where applicable.

Prior to instrument delivery, the instrument shall be subjected to a minimum of 8 thermal-vacuum temperature cycles, at least four of which shall be at the instrument level. As a part of observatory testing, they will be subjected to at least 4 thermal-vacuum temperature cycles. During any thermal-vacuum cycling, the rate of temperature change shall not exceed 20 degrees C per hour, and soak times at temperature extremes shall not start until equilibrium is reached. For the instrument-level tests, the instrument shall be subjected to a minimum of 4 thermal-vacuum temperature cycles, during which the instrument shall be soaked for a minimum of 16 hours at each temperature extreme of each cycle. The developer shall state in the FATFP, the proposed testing scenario for the instrument and its components. The hardware at all levels of assembly shall be operated and its performance monitored throughout the test. Instrument turn-on capability shall be demonstrated at least twice during the low and high temperature extremes. The ability to function through the voltage breakdown region, if applicable, shall be demonstrated. Figure 4-1 represents the thermal vacuum profile.

Temperature excursions during the cycling of components shall be sufficiently large to detect latent defects in workmanship. For components that are determined by analysis to be insensitive to vacuum effects relative to temperature levels and temperature gradients, the gradient may be satisfied by temperature cycling at normal room pressure in an air or gaseous nitrogen environment. Additional margin and cycles; however, are required if air temperature is employed.

4.6.2 THERMAL BALANCE

The validity of the thermal design and the ability of the thermal control system to maintain the hardware within the established thermal limits for the mission shall be demonstrated by test in accordance with the SRD "Common Section" and Statement of Work.

The capability of the thermal control system shall be demonstrated in the same manner. If the flight hardware is not used in the test of the thermal control system, verification of critical thermal properties (such as those of the thermal control coatings) shall be performed to demonstrate similarity between the item tested and the flight hardware.

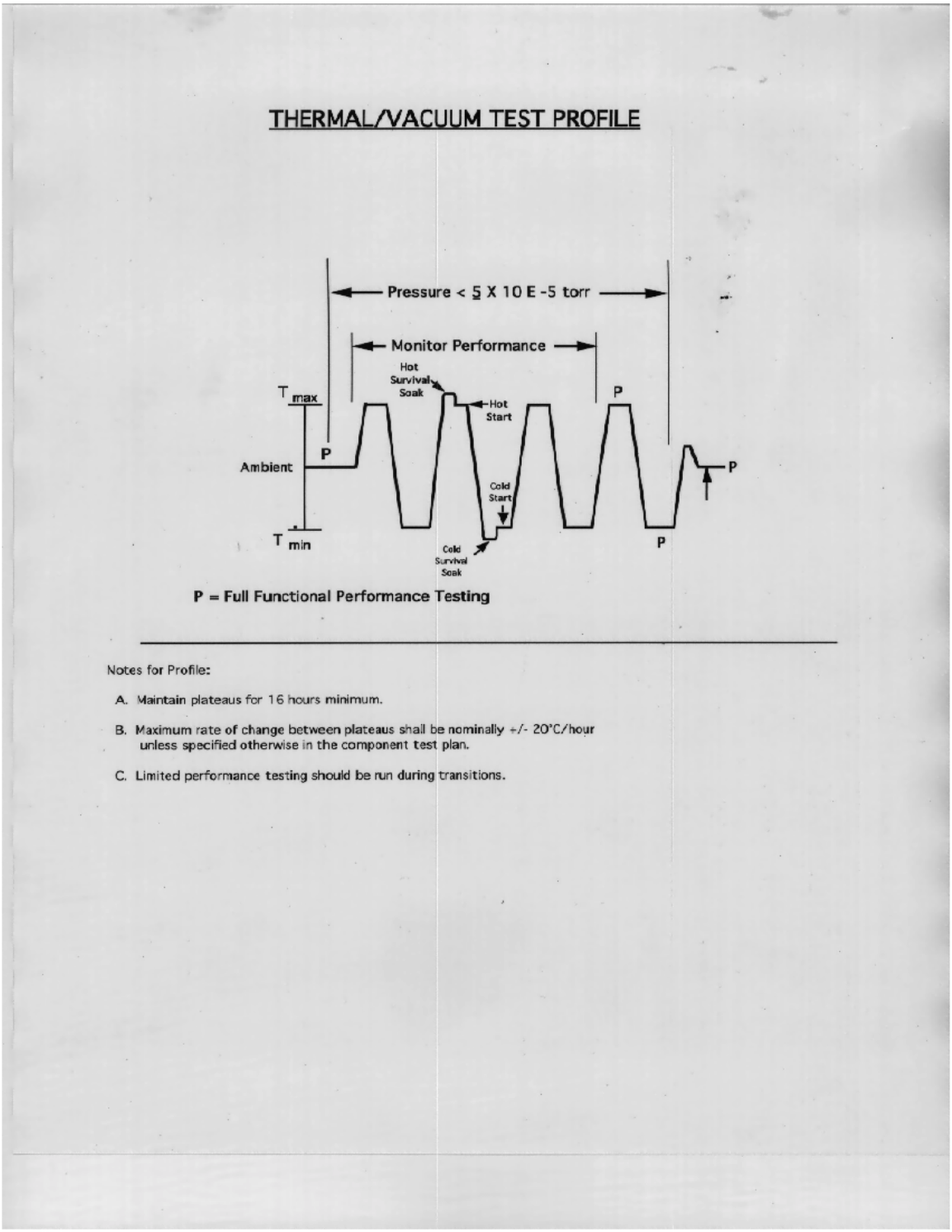
4.6.3 TEMPERATURE - HUMIDITY: TRANSPORTATION AND STORAGE

An analysis and, when necessary, tests shall demonstrate that flight hardware that is not maintained in a controlled temperature-humidity environment to within demonstrated acceptable limits, will perform satisfactorily after (or, if so required, during) exposure to the uncontrolled environment.

The test shall include exposure of the hardware to the following extremes of temperature and humidity:

Ten (10) degrees C and 10% RH (but not greater than 90% RH) higher and lower than those predicted for the transportation and storage environments. The exposure at each extreme shall be for a period of six (6) hours.

Figure 4-1 Thermal/Vacuum Test Profile



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5.0 ELECTRONIC PACKAGING AND PROCESSES REQUIREMENTS

5. 1 GENERAL

The developer shall plan and implement an Electronic Packaging and Processes Program to assure that all electronic packaging technologies, processes, and workmanship activities selected and applied meet mission objectives for quality and reliability.

5. 2 WORKMANSHIP

The developer shall use the following NASA/Industry preferred standards. As stated in section 1.4.2, these workmanship standards shall be imposed on the developer's subcontractors and other suppliers.

NASA-STD-8739.3, Requirements for Soldered Electrical Connections
NASA-STD-8739.4, Requirements for Cabling and Crimping
NASA-STD-8739.1, Requirements for Conformal Coating and Staking of Printed Wiring Boards
NHB 5300.4 (3M), Requirements for Surface Mount
NASA-STD-8739.7, Requirements for Electrostatic Discharge Control
IPC-2221, Generic Standard on Printed Board Design
IPC-2222, Sectional Design Standard for Rigid Organic Printed Boards
IPC-RB-6011 & 6012, Qualification/Performance Specification for Rigid Printed WiringBoards
GSFC Supplement S-312-P003, Process Specification for Rigid Printed Wiring Boards for Space Applications and Other High Reliability Uses

Alternate workmanship standards may be used when approved by the project. The developer shall submit, for review and acceptance, the alternate standard and the differences between the alternate standard and the required standard prior to project approval.

The developer shall provide a test coupon for each PWB used in the flight to GSFC for approval as a precondition to board population. The coupon shall be per the design requirements of GSFC S-312-P-003 and shall only be removed from the flight PWB panel after the panel has been through all manufacturing processes. The coupon shall be “as produced” by the vendor; that is, it shall not have seen any processes not experienced by the PWB panel (including metallographic preparation techniques or thermal excursions). The coupon shall be clearly identified with the part number, serial number, vendor identification and date code or production lot number.

As an alternative, the developer may have coupons evaluated by a laboratory that has been approved by the GSFC Project Office in writing before the coupons are released for evaluation. The developer shall provide test reports for these coupons. The flight PWB shall not be assembled prior to notification that the representative coupon has passed laboratory evaluation by the GSFC-approved laboratory.

5. 3 NEW/ADVANCED PACKAGING TECHNOLOGIES

New and/or advanced packaging technologies (e.g., MCMs, stacked memories, chip on board) that have not previously been used in space flight applications shall be reviewed and approved through the Parts Control Board (PCB) as defined in Section 6. The developer shall provide a detailed Technology Validation Assessment Plan for each new technology, which identifies the evaluations and data necessary for acceptance of the new/advanced technology for reliable use and conformance to project requirements. New/advanced technologies shall be part of the Parts Identification List (PIL) and Materials Identification List (MIL) as defined in sections 6 and 7.

6.0 PARTS REQUIREMENTS

6. 1 GENERAL

The developer shall plan and implement an Electrical, Electronic, and Electromechanical (EEE) Parts Control Program to assure that all parts selected for use in flight hardware meet mission objectives for quality and reliability.

The developer shall prepare a Parts Control Plan (PCP) describing the approach and methodology for implementing the Parts Control Program. The PCP will also define the developer's criteria for parts selection and approval based on the guidelines of this section. The PCP will be made a part of the proposal for review in accordance with contract delivery requirements.

6. 2 ELECTRICAL, ELECTRONIC, AND ELECTROMECHANICAL (EEE) PARTS

All part commodities identified in the NASA Parts Selection List are considered EEE parts and will be subjected to the requirements set forth in this section. Custom or advanced technology devices such as custom hybrid microcircuits, detectors, Application Specific Integrated Circuits (ASIC), and Multi-Chip Modules (MCM) shall also be subject to parts control appropriate for the individual technology (see 6.2.2.1).

6.2.1 PARTS CONTROL BOARD

The developer shall establish a Parts Control Board (PCB) or a similar documented system to facilitate the management, selection, standardization, and control of parts and associated documentation for the duration of the contract. The PCB shall be responsible for the review and approval of all parts for conformance to established criteria, and for developing and maintaining a Parts Identification List (PIL). In addition, the PCB shall be responsible for all parts activities such as failure investigations, disposition of non-conformances, and problem resolutions. PCB operating procedures shall be included as part of the PCP.

6.2.1.1 PCB Meetings

PCB meetings shall be convened on a regular basis or as needed. GSFC may participate in PCB meetings and shall be notified in advance of all upcoming meetings. If participating, GSFC shall have voting rights at PCB meetings. The developer will maintain meeting minutes or records to document all decisions made and a copy provided to GSFC within three days of convening the meeting. GSFC shall retain the right to overturn decisions involving non-conformances within ten days after receipt of meeting minutes. PCB activities may be audited by GSFC on a periodic basis to assess conformance to the developer's PCP.

6.2.2 PARTS SELECTION AND PROCESSING

All parts shall be selected and processed in accordance with the GSFC 311-INST-001 "Instructions for EEE Parts Selection, Screening and Qualification". All application notes in 311-INST-001 will apply. If the parts to be used on the EDU are procured by methods 1 through 4 of GSFC 311-INST-001, full paperwork and documentation (i.e. pedigree) are not required. Parts shall be procured to Class 1 unless otherwise justified and approved by GSFC in accordance with the reliability program. These requirements will then become the established criteria for parts selection, testing, and approval for the duration of the project, and will be documented in the PCP. Parts selected from the NASA Parts Selection List, MIL-STD-975, and the GSFC Preferred Parts List (PPL) are considered to have met all criteria of 311-INST-001 for the appropriate parts quality level, and may be approved by the PCB provided all mission application requirements (performance, de-rating, radiation, etc.) are met.

6.2.2.1 Custom Devices

In addition to applicable requirements of 311-INST-001, custom microcircuits, hybrid microcircuits, MCM, ASIC, etc. planned for use by the developer shall be subjected to a design review. The review may be conducted as part of the PCB activity. The design review will address, at a minimum, de-rating of elements, method used to assure each element reliability, assembly process and materials, and method for assuring adequate thermal matching of materials.

6.2.3 DE-RATING

All EEE parts shall be used in accordance with the de-rating guidelines of the NASA Preferred Parts List (PPL-21). The developer's de-rating policy may be used in place of the NASA Parts Selection List guidelines and will be submitted with the PCP. The developer shall maintain documentation on parts de-rating analysis and shall make it available for GSFC review.

6.2.4 RADIATION HARDNESS

All parts shall be selected to meet their intended application in the predicted mission radiation environment. The radiation environment consists of two separate effects, those of total ionizing dose and single-event effects. The developer shall document the analysis for each part with respect to both effects. The possibility of displacement damage shall also be considered for parts susceptible to this effect.

6.2.5 VERIFICATION TESTING

Verification of screening or qualification tests by re-testing is not required unless deemed necessary as indicated by failure history, GIDEP Alerts, or other reliability concerns. If required, testing shall be in accordance with 311-INST-001 as determined by the PCB. The developer, however, shall be responsible for the performance of supplier audits, surveys, source inspections, witnessing of tests, and/or data review to verify conformance to established requirements.

6.2.6 DESTRUCTIVE PHYSICAL ANALYSIS

A sample of each lot date code of microcircuits, hybrid microcircuits, and semiconductor devices shall be subjected to a Destructive Physical Analysis (DPA). All other parts may require a sample DPA if it is deemed necessary as indicated by failure history, GIDEP Alerts, or other reliability concerns. DPA tests, procedures, sample size and criteria shall be as specified in GSFC specification S-311-M-70, Destructive Physical Analysis. Developer's procedures for DPA may be used in place of S-311-M-70 and shall be submitted with the PCP. Variation to the DPA sample size requirements, due to part complexity, availability or cost, shall be determined and approved by the PCB on a case-by-case basis.

6.2.7 PARTS AGE CONTROL

Parts drawn from controlled storage after 5 years from the date of the last full screen shall be subjected to a full 100 percent re-screen and sample DPA. Alternative test plans may be used as determined and approved by the PCB on a case-by case basis. Parts over 10 years from the date of the last full screen or stored in other than controlled conditions where they are exposed to the elements or sources of contamination shall be submitted to the PCB for approval prior to use.

6. 3 PARTS LISTS

The developer shall create and maintain Parts Identification List (PIL) for the duration of the project in accordance with the CDRL. The PCB shall assure standardization and the maximum use of parts listed in the PIL. An As-Built Parts and Materials List (ABPML) shall also be prepared and submitted to GSFC in accordance with the contract delivery requirements. The ABPML is generally the final PIL with additional as-built information, such as parts manufacturers and lot date code.

6. 4 ALERTS

The developer shall be responsible for review and disposition of Government Industry Data Exchange Program (GIDEP) Alerts for applicability to the parts proposed for use. In addition, any NASA Alerts and Advisories provided to the developer by GSFC shall be reviewed and dispositioned. Alert applicability, impact, and corrective actions shall be documented and be made available for GSFC review.

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7.0 MATERIALS, PROCESSES AND LUBRICATION REQUIREMENTS

7. 1 GENERAL REQUIREMENTS

The developer shall implement a comprehensive Materials and Processes Plan beginning at the design stage of the hardware. The plan shall help ensure the success and safety of the mission by the appropriate selection, processing, inspection, and testing of the materials, processing and lubricants employed to meet the operational requirements for ATMS. Materials and lubrication assurance approval is required for each usage or application in space-flight hardware. Materials selection shall be in accordance with the SRD "Common Section" and as defined below.

7. 2 MATERIALS SELECTION REQUIREMENTS

In order to anticipate and minimize materials problems during space hardware development and operation, the developer shall, when selecting materials and lubricants, consider potential problem areas such as radiation effects, thermal cycling, stress corrosion cracking, galvanic corrosion, hydrogen embrittlement, lubrication, contamination of cooled surfaces, composite materials, atomic oxygen, useful life, vacuum outgassing, toxicity, flammability and fracture toughness, as well as the properties required by each material usage or application.

7.2.1 MATERIALS IDENTIFICATION LIST

The contractor shall maintain a Materials Identification List (MIL) of all materials planned for use in flight hardware, regardless of their approval status. The initial MIL and subsequent updates shall be submitted to GSFC in accordance with the contract delivery requirements. An As-Built Materials List (ABML) shall also be prepared and submitted to GSFC in accordance with the contract delivery requirements. The ABML is generally the final MIL with additional as-built information such as materials manufacturers.

7.2.2 COMPLIANT MATERIALS

The developer shall use compliant materials in the fabrication of flight hardware to the extent practicable.

In order to be compliant, a material must be used in a conventional application and meet the applicable selection criteria:

- Hazardous materials requirements, including flammability, toxicity and compatibility as specified in Eastern and Western Range 127-1 Range Safety Requirements, Sections 3.10 and 3.12 and NASA-STD-6001;
- Vacuum Outgassing requirements as defined in the SRD “Common Section”;
- Stress corrosion cracking requirements as defined in MSFC-SPEC-522.

A compliant material does not require a Materials Usage Agreement (MUA).

7.2.3 NON-COMPLIANT MATERIALS

A material that does not meet the requirements of the applicable selection criteria above, or meets the requirements above but is used in an unconventional application, shall be considered to be a non-compliant material. The proposed use of a non-compliant material requires that a Materials Usage Agreement (MUA) and/or a Stress Corrosion Evaluation Form or developer's equivalent form, be submitted to GSFC for approval in accordance with the CDRL.

7.2.3.1 Materials Used in "Off-the-Shelf-Hardware"

"Off-the-shelf hardware" for which a detailed materials list is not available and where the included materials cannot be easily identified and/or changed shall be treated as non-compliant. The developer shall define on a MUA what measures will be used to ensure that all materials in the hardware are acceptable for use. Such measures might include any one, or a combination, of the following: hermetic sealing, vacuum bake-out, material changes for known non-compliant materials, etc. When a vacuum bake-out is the selected method, it shall incorporate a quartz crystal microbalance (QCM) and cold finger to enable a determination of the duration and effectiveness of the bake-out as well as compliance with the satellite contamination plan and error budget.

7.2.4 CONVENTIONAL APPLICATIONS (DEFINITION)

Conventional applications or usage of materials is the use of compliant materials in a manner for which there is extensive satisfactory aerospace heritage.

7.2.5 NON-CONVENTIONAL APPLICATIONS (DEFINITION)

The proposed use of a compliant material for an application for which there is limited satisfactory aerospace usage shall be considered a non-conventional application. In that case, the material usage will be verified for the desired application on the basis of test, similarity, analyses, inspection, existing data, or a combination of those methods.

7.2.6 POLYMERIC MATERIALS

Material acceptability shall be determined on the basis of flammability, toxicity, vacuum outgassing and all other materials properties relative to the application requirements and usage environment.

7.2.7 SHELF-LIFE-CONTROLLED MATERIALS

Polymeric materials that have a limited shelf life shall be controlled by a process that identifies the start date (manufacturer's processing, shipment date, or date of receipt, etc.), the storage conditions associated with a specified shelf life, and expiration date. Materials such as o-rings, rubber seals, tape, uncured polymers, lubricated bearings and paints shall be included. The use of materials with expired date code requires that the

developer demonstrate by means of appropriate tests that the properties of the materials have not been compromised for their intended use; such materials shall be approved by GSFC by means of a waiver. When a limited-life piece part is installed in a subassembly, the subassembly item shall be included in the Limited-Life Items List and submitted in accordance with the CDRL.

7.2.8 INORGANIC MATERIALS

The developer shall include inorganic materials and composites on the MIL. In addition, the developer may be requested to submit supporting applications data. The criteria specified in MSFC-SPEC-522 shall be used to determine that metallic materials meet the stress corrosion cracking (SCC) criteria. An MUA and a SCC evaluation form shall be submitted for each material usage that does not comply with the MSFC-SPEC-522 SCC requirements.

7.2.8.1 Fasteners

The developer shall comply with the procurement documentation and test requirements for flight hardware and critical ground support equipment fasteners contained in GSFC S-313-100, Goddard Space Flight Center Fastener Integrity Requirements. Material test reports for fastener lots shall be submitted for information.

Fasteners made of plain carbon or low alloy steel shall be protected from corrosion. When plating is specified, it shall be compatible with the space environment. On steels harder than RC 33, plating shall be applied by a process that is not embrittling to the steel.

7.2.9 LUBRICATION

The developer shall prepare and document a lubrication usage list as part of the MIL in accordance with the CDRL. In addition, the developer may be requested to submit supporting applications data.

Lubricants shall be selected for use with materials on the basis of valid test results that confirm the suitability of the composition and the performance characteristics for each specific application, including compatibility with the anticipated environment and contamination effects.

All lubricated mechanisms shall be qualified by life testing in accord with the life test plan or heritage of an identical mechanism used in identical applications.

7. 3 PROCESS SELECTION REQUIREMENTS

The developer shall prepare and document a material process utilization list as part of the MIL in accordance with the CDRL. A copy of any process shall be submitted for review upon request. Manufacturing processes (e.g., lubrication, heat treatment, welding, chemical or metallic coatings), shall be carefully selected to prevent any unacceptable material property changes that could cause adverse effects of materials applications.

7. 4 PROCUREMENT REQUIREMENTS

7.4.1 PURCHASED RAW MATERIALS

Raw materials purchased by the developer shall be accompanied by the results of nondestructive, chemical and physical tests, or a Certificate of Compliance.

7.4.2 RAW MATERIALS USED IN PURCHASED PRODUCTS

The developer shall require that the supplier meet the requirements of 7.4.1 and provide on request the results of acceptance tests and analyses performed on raw materials.

8.0 RELIABILITY REQUIREMENTS

8. 1 GENERAL RELIABILITY REQUIREMENTS

The developer shall plan and implement a reliability program that interacts effectively with other project disciplines, including systems engineering, hardware design, and product assurance. The program shall be tailored according to the risk level in order to:

a. Demonstrate that redundant functions, including alternative paths and work-arounds, are independent to the extent practicable;

b. Demonstrate that stress applied to parts is not excessive;

c. Identify single failure items (points), their effect on the attainment of mission objectives, and possible safety degradation;

d. Show that reliability design is in keeping with mission design life and that it is consistent among systems, subsystems, instruments and components;

e. Identify limited-life items and ensure that special precautions are taken to conserve their useful life for on-orbit operations;

f. Select significant engineering parameters for the performance of trend analysis to identify performance trends during pre-launch activities;

g. Ensure that the design allows for ease of replacement of parts and components and that redundant paths are easily monitored.

8. 2 RELIABILITY ANALYSES

Reliability analyses shall be performed concurrently with design so that identified problem areas can be addressed for timely consideration of corrective action.

8.2.1 FAILURE MODES AND EFFECTS ANALYSIS AND CRITICAL ITEMS LIST

A Failure Modes and Effects Analysis (FMEA) shall be performed early in the design phase to identify system design problems. As additional design information becomes available the FMEA shall be refined.

Failure modes shall be assessed at the component interface level. Each failure mode shall be assessed for the effect at that level of analysis, the next higher level and upward. The failure mode shall be assigned a severity category based on the most severe effect caused by a failure. Mission phases, for example, launch, deployment, on-orbit operation and retrieval, shall be addressed in the analysis.

Severity categories shall be determined in accordance with Table 8-1:

TABLE 8-1

SEVERITY CATEGORIES

Category	Severity Definition
1	Catastrophic Failure modes that could result in serious injury or loss of life (flight or ground personnel), or loss of launch vehicle.
1R	Failure modes of identical or equivalent redundant hardware items that, if all failed, could result in category 1 effects.
1S	Failure in a safety or hazard monitoring system that could cause the system to fail to detect a hazardous condition or fail to operate during such condition and leads to Severity Category 1 consequences.
2	Critical Failure modes that could result in loss of one or more mission objectives as defined by the GSFC project office.
2R	Failure modes of identical or equivalent redundant hardware items that could result in Category 2 effects if all failed.
3	Significant Failure modes that could cause degradation to mission objectives.
4	Minor Failure modes that could result in insignificant or no loss to mission objectives

FMEA analysis procedures and documentation shall be performed in accordance with documented procedures. Failure modes resulting in Severity Categories 1, 1R, 1S or 2 shall be analyzed at greater depth, to the single parts if necessary, to identify the cause of failure.

Results of the FMEA shall be used to evaluate the design relative to requirements (for example, no single instrument failure shall prevent removal of power from the instrument). Identified discrepancies shall be evaluated by management and design groups for assessment of the need for corrective action.

The FMEA shall analyze redundancies to ensure that redundant paths are isolated or protected such that any single failure that causes the loss of a functional path shall not affect the other functional path(s) or the capability to switch operation to that redundant path.

All failure modes that are assigned to Severity Categories 1, 1R, 1S and 2, shall be itemized on a Critical Items List (CIL) and submitted with the FMEA report. Rationale for retaining the items shall be included on the CIL.

The FMEA shall be submitted to GSFC for review in accordance with the CDRL.

8.2.2 PARTS STRESS ANALYSES

Each application of electrical, electronic, and electromechanical (EEE) parts, shall be subjected to stress analyses for conformance with the applicable derating guidelines). The analyses shall be performed at the most stressful values that result from specified performance and environmental requirements (e.g. temperature, voltage) on the assembly or component. The analyses shall be performed in close coordination with the packaging reviews and thermal analyses, and it shall be required input data for component-level design reviews). The analyses with summary sheets and updates shall be submitted in accordance with the CDRL.

8.2.3 WORST CASE ANALYSES

Worst Case Analyses shall be performed on circuits where failure results in a severity category of 2 or higher. The most sensitive design parameters, including those that are subject to variations that could degrade performance, shall be subjected to the analysis. Adequacy of margins in the design of electronic circuits, optics, electromechanical and mechanical items shall be demonstrated by analyses or test or both.

The analyses shall consider all parameters set at worst case limits and worst case environmental stresses for the parameter or operation being evaluated. Depending on mission parameters and parts selection methods, part parameter values for the analysis typically include the following: manufacturing variability, variability due to temperature, aging effects of environment, and variability due to cumulative radiation. The analyses shall be updated in keeping with design changes. The analyses and updates shall be submitted in accordance with the CDRL.

8.2.4 RELIABILITY ASSESSMENTS

The developer shall perform comparative numerical reliability assessments in order to:

a. evaluate alternative design concepts, redundancy and cross-strapping approaches, and part substitutions; and identify the elements of the design which are the greatest detractors of system reliability;

b. Identify those potential mission limiting elements and components that will require special attention in part selection, testing, environmental isolation, and/or special operations;

c. assist in evaluating the ability of the design to achieve the mission life requirement and other reliability goals and requirements as applicable; and

d. evaluate the impact of proposed engineering change and waiver requests on reliability.

The assessments and updates shall be submitted in accordance with the CDRL. The results of reliability assessment results shall be reported at CDR and ΔCDR.

8. 3 ANALYSIS OF TEST DATA

The developer shall fully utilize test information during the normal test program to assess flight equipment reliability performance and identify potential or existing problem areas.

8.3.1 TREND ANALYSES

The developer shall assess all subsystems and components to determine measurable parameters that relate to performance stability. Selected parameters shall be monitored for trends starting at component acceptance testing and continuing during the system integration and test phases. The monitoring shall be accomplished within the normal test framework; i.e., during functional tests, environmental tests, etc. The developer shall establish a system for recording and analyzing the parameters as well as any changes from the nominal even if the levels are within specified limits. Trend analysis data shall be reviewed with the operational personnel prior to launch, and the operational personnel shall continue recording trends throughout mission life. A list of subsystem and components to be assessed and the parameters to be monitored and the trend analysis reports shall be submitted for information in accordance with the CRDL.

8. 4 LIMITED-LIFE ITEMS

Limited-Life items shall be identified and reported by means of a Limited-Life Items List, which shall be submitted for approval in accordance with the CDRL. Records shall be maintained that will allow evaluation of the cumulative stress (time and/or cycles) for limited-life items, starting when useful life is initiated and indicating the project activity that stressed the items. The use of an item whose expected life is less than its mission design life shall be approved by GSFC by means of a waiver in accordance with the CDRL.

9.0 QUALITY ASSURANCE REQUIREMENTS

9. 1 GENERAL REQUIREMENTS

The developer shall have a Quality Management System that meets the minimum requirements of ANSI/ASQ Q9001-1994. The developer's Quality Manual shall be delivered in accordance with the CDRL. The developer shall set forth his methods for meeting the quality assurance (QA) requirements of the project in all its phases and shall ensure that controls are carried out according to schedule. GSFC shall be kept informed of the status of the QA program at the monthly program status reviews.

9. 2 SUPPORT OF DESIGN REVIEWS

QA personnel shall participate in the design reviews described in Section 2.

9. 3 DOCUMENT CHANGE CONTROL

The developer shall ensure control of all documents and changes thereto that affect the hardware and software. The developer's Configuration Management (CM) Plan shall be submitted in accordance with the CDRL. Quality assurance personnel shall ensure that documents and changes are controlled in accordance with the developer's CM Plan. The developer shall ensure that the effectivity of documents and changes is clearly specified, changes are accomplished on affected articles, and changed articles are appropriately identified. Documents shall be kept current and all fabrication, inspections, and tests shall be performed according to the most recent drawings and changes. The inspection record of the product shall indicate the change level with which it is in compliance.

The issue numbers of the drawings and specifications to which the particular hardware has been fabricated, inspected, and tested shall be documented as the as-built configuration. Evidence shall be provided of compliance with the as-built documentation as a basis for acceptance of the hardware.

A developer QA representative and the NASA/GSFC COTR shall be members of the Configuration Control Board (CCB). Unanimous board member agreement is required for change approval. The QA activities shall be defined in the CM Plan and described in detail in the relevant quality assurance documentation.

9. 4 IDENTIFICATION AND TRACEABILITY

The developer shall maintain a product identification and tracking system. A unique part or type number, consistent with the configuration management system for the contract shall identify each product. Where control of individual products or lots of products is required, date codes, lot numbers, serial numbers, or other identification shall be used as appropriate. Serial numbers and lot numbers shall be assigned in consecutive order.

The system shall be capable of retrieving the identification and serialization record at the subassembly level. It shall also be capable of retrieving fabrication, processing and test records of identifiable articles, materials and parts (by part lot date code) in the event verification of the articles, materials or parts becomes necessary. Beginning at the subassembly level and continuing through the end product, the system shall be capable of

tracing the location of any individual subassembly in the mission hardware at any given level of process, assembly, or test. Identification and serialization data lower than that for subassemblies shall be maintained in the manufacturing and processing records and shall contain date code, lot numbers, and manufacturer of the item; this includes mechanical parts and fasteners. The developer is encouraged to make use of his existing identification and traceability system. Serial numbers of scrapped products shall not be reused.

9. 5 PROCUREMENT REQUIREMENTS

The following detailed quality assurance requirements, as applicable, shall be included or referenced in the procurement documents. The government reserves the right to review purchasing documentation.

9.5.1 PRODUCT CHANGES

The supplier shall notify the developer of proposed changes to products (including changes in design, fabrication methods, processes or location, and changes, which may affect the quality or intended end use of the item). The supplier shall submit these changes to the developer for processing in accordance with the developer's CM Plan. When the developer procures a proprietary item, the supplier shall also notify the developer of those changes.

9.5.2 PURCHASED RAW MATERIALS

Raw materials purchased by the developer shall be accompanied by a Certificate of Conformance , or the results of chemical, and physical tests performed on the lots of material delivered. When materials is purchased, the suppliers of raw materials shall be required to furnish specimens for chemical and physical tests in the event that the materials are later used for critical design applications.

9.5.3 RAW MATERIALS USED IN PURCHASED PRODUCTS

The supplier shall document and make available to the developer on request the results of acceptance tests and analyses performed on raw materials.

9.5.4 AGE CONTROL AND LIMITED-LIFE PRODUCTS

Records shall be kept on products that have definite characteristics of quality degradation or drift with use, age or storage conditions. These shall include any materials to be used in fabrication, the shelf life controlled items, and the Limited Life items. The records shall note the date, test time, or cycle when useful life was initiated, the life or cycles used, and the date, test time, or cycle when useful life will be expended.

9.5.5 INSPECTION AND TEST RECORDS

The developer shall specify that the supplier maintain inspection and test records as evidence of inspection and test results. The developer shall also specify records that are to be provided with the deliverable item.

9.5.6 GOVERNMENT SOURCE INSPECTION (GSI)

When the Government elects to perform inspection at a supplier's plant, the following statement shall be included in the procurement document:

"All work on this order is subject to inspection and test by the Government at any time and place. The Government quality representative who has been delegated NASA quality assurance functions on this procurement shall be notified immediately upon receipt of this order. The Government representative shall also be notified 48 hours in advance of the time that articles or materials are ready for inspection or test."

9.5.7 PROCUREMENTS THAT DO NOT REQUIRE GSI

Procurements that do not require GSI shall include the following statement:

"The Government has the right to inspect any or all of the work included in this order at the supplier's plant."

9.5.8 WELD FILLER METAL AND FASTENER INTEGRITY

Weld rods, weld wire, and such procurements shall meet the requirements of NASA-STD-5006.

Procurement, application, screening, inspection and test of fasteners shall conform to the requirements of GSFC specification S-313-100.

9.5.9 DEVELOPER QA ACTIVITY AT SOURCE

When developer QA activity is required at a supplier's plant, the procurement document shall so indicate.

9.5.10 REVIEW AND APPROVAL OF PROCUREMENT DOCUMENTS

Quality assurance personnel shall review and approve procurement documents before their release to ensure that applicable requirements of this document are included. The reviews shall be documented.

9.5.11 PROCUREMENT REVIEW BY THE GOVERNMENT

The developer shall forward procurement documents to the Government representative to review for compliance with contract requirements and to determine the need for Government source inspection. Such Government inspection shall not replace developer source inspection or relieve the developer of his responsibilities for product reliability, quality, and safety.

9.5.12 Developer Source Inspection

The developer shall perform source inspection at the subcontractor's or supplier's facilities when directed by the procurement documentation or when one or more of the following conditions exist:

a. In-process, end-item controls, or tests that are destructive in nature prevent the developer from verifying quality in the developer's facility;

b. It is not feasible or economical for the developer to determine the quality of procured articles solely by inspections or tests performed at the developer's facility;

c. Qualification tests are to be performed by the subcontractor or supplier;

d. Products are shipped directly from the source to NASA, by-passing the developer's inspection facilities.

9.5.13 Developer Receiving Inspection

A controlled, documented receiving inspection system that covers all purchased products is required to ensure compliance with procurement documents.

All procured products shall be processed through an incoming inspection and testing system prior to fabrication. Nondestructive evaluation (NDE) may be used provided controlled documentation and certified personnel are employed. The receiving-inspection system shall consist of the following:

a. Procured products shall be accompanied by inspection and test records as evidence that the supplier is in compliance with purchase requirements and shall be accompanied by the required data directly traceable to the products. The records shall give evidence of developer and Government source inspection;

b. Inspections and tests shall be conducted in accordance with written procedures on selected characteristics of the products to verify their acceptability. Particular emphasis shall be placed on the selection of characteristics that have not been developer-source inspected and those for which nonconformances are difficult to detect during subsequent inspection and test. Test results shall be compared on a sample basis with test results provided by the supplier. Disassembly shall be performed periodically for detailed verification when required by the procurement document or the procedures;

c. The supplier's age control and limited-life product records shall be updated to reflect the receiving inspection activity;

d. When, during the design phase, it is determined that a material has a critical application, specimens of the material shall be delivered with the purchased product and be subjected to chemical and physical tests. Chemical analyses and physical tests shall also be performed on samples randomly selected from each lot of materials in order to verify the product's conformance to specification requirements. It shall be verified that all weld filler metal is in compliance with NASA-STD-5006;

e. Products and their records shall show acceptance or nonconformance status when released from receiving-inspection, and the products shall be protected for subsequent handling or storage. Nonconforming products shall be submitted for Material Review Board (MRB) action. Items awaiting inspection or test results or MRB action shall be segregated;

f. Sampling inspection shall be used where tests are destructive or for such items as nuts, bolts, and fasteners that are not used as critical attachments);

g. Receiving inspection and test records shall be maintained, including copies of documents submitted by the supplier.

9. 6 FABRICATION CONTROL

9.6.1 DOCUMENTATION

The developer shall use a documentation system (consisting of items such as fabrication orders, assembly orders, shop travelers, and repair procedures) to control the flow of hardware through the manufacturing phase. Controls shall ensure that only conforming product is released and used during fabrication and that those not required for the operation involved are removed from the work area and properly stored. Traceability shall be maintained in accordance with par. 9.4. Fabrication documents shall include or reference:

a. Nomenclature and identification of the article;

b. Tooling, jigs, fixtures, and other equipment to be used;

c. Characteristics and tolerances to be obtained;

d. Detailed procedures for controlling processes;

e. Special conditions to be maintained such as environmental conditions or precautions to be observed;

f. Workmanship standards;

g. Controls for parts, materials, and articles, which have definite characteristics of quality degradation or drift with age, use, or storage. The controls shall include requirements for recording and maintaining dates, time, or cycles for determining end of life;

h. Traceability to the individual and equipment performing each fabrication and assembly operation.

Developer assurance personnel shall ensure that manufacturing operations are in compliance with up-to-date controlling documents.

9.6.2 PROCESS EVALUATION AND CONTROL

Controls shall be implemented for processes for which high uniform quality cannot be ensured by inspection of products alone. Nondestructive evaluation (NDE) methods may be used provided controlled documentation and certified personnel are employed. Process procedures shall be prepared and shall describe the following:

a. Preparation of the processing equipment, solutions and materials;

b. Preparation of the products to be processed;

c. Detailed processing operations;

d. Conditions to be maintained during each phase of the process including environmental controls;

e. Methods of verifying the adequacy of processing materials, solutions, equipment, environments, and their associated control parameters;

f. Inspection and test provisions;

g. Records for documenting the results of process inspection, test, and verification.

The developer shall provide for the certification of equipment used in selected processes. Records of certification test results shall be maintained. Equipment shall be recertified as indicated by the results of quality surveys, inspections, tests or when changes are made that may affect process integrity.

9. 7 CONTAMINATION CONTROL

The quality assurance personnel shall ensure that the developer is in compliance with the requirements of the Contamination Control Plan during all phases of the program.

9. 8 ELECTROSTATIC DISCHARGE CONTROL

The developer shall implement a program to control Electrostatic Discharge (ESD) for electrical and electronic parts, assemblies, and equipment susceptible to damage caused by static electricity. The program shall address provisions for work area protection, handling procedures, training, hardware protective covering, packaging for delivery, and Quality Assurance verification of conformance. Procedures shall be developed in accordance with NASA-STD-8739.7. The developer shall also invoke applicable requirements for ESD control on subcontractors and suppliers.

9. 9 NONCONFORMANCE CONTROL

The developer shall operate a closed-loop nonconformance control system for failures and discrepancies. The system shall include provisions for the following:

a. Documentation of each nonconformance traceable to the specific product on which it occurred;

b. Assignment of a unique and traceable document number for each failure and for those discrepancies designated for Material Review Board (MRB) action;

c. Description of the nonconformance and the required characteristic or design criteria;

d. Conducting and documenting analyses and examinations to determine the cause;

e. Implementing and documenting timely and effective remedial and preventive action on the products and applicable documents;

f. Disposition of the nonconforming product;

g. Signatures of authorized personnel on the appropriate nonconformance documents;

h. Accumulating data in summary reports;

i. Performing analyses from the part level of assembly and higher to identify adverse trends and to provide for their correction;

j. Closeout of nonconformance documentation after verifying that effective remedial and preventive actions have been taken on the nonconforming articles and any other articles affected.

On request, a report of the analyses required by items d. and i. shall be made available to NASA. Products that depart from specified requirements shall be identified and, if practicable, shall be isolated for review action. The system shall include provisions for

controlling nonconforming products that cannot be isolated from the normal channels of manufacture.

9.9.1 CONTROL, DISPOSITION, AND REPORTING OF DISCREPANCIES

9.9.1.1 Documentation

Documentation of discrepancies shall start with the receipt of procured parts, materials, or other products, or the initiation of in-house manufacturing, whichever occurs first. Each discrepancy shall be documented on the appropriate developer form promptly after discovery.

9.9.1.2 Initial Review Dispositions

Discrepant products shall be reviewed by developer QA and, as appropriate, engineering personnel and shall be subjected to one of the following dispositions:

a. Return for Rework or Completion of Operations - The product shall be returned using established and approved documents and operations. During rework, the product shall be resubmitted to normal inspection and tests;

b. Scrap in accordance with Government-approved developer procedures for identifying, controlling and disposing of scrap;

c. Return to Supplier - The developer shall provide the supplier with nonconformance information and assistance, as necessary, to permit remedial and preventive action;

d. Submit to Material Review Board - When the dispositions, as described above, are not appropriate, the discrepant products shall be submitted to the Material Review Board (MRB) for final disposition.

Products disposed of without referral to MRB shall be subject to review by the Government quality representative. Initial review dispositions shall be recorded on nonconformance documentation.

9.9.1.3 Material Review Board (MRB)

MRB decisions on nonconformance shall be submitted to NASA in accordance with the CDRL herein. Other provisions of the MRB follow:

a. Membership. The MRB shall comprise, as a minimum, the following members:

   1) Developer quality representative, chairman;

2) Developer engineering representative;

3) Government quality representative.

The developer shall select members on the basis of technical competence. The Government representative on the board shall approve the membership.

Note: Unanimous agreement of the MRB membership is required for all dispositions.

b. Responsibilities - The MRB shall have the responsibility to:

1) Determine disposition of submitted products;

2) Ensure that remedial and preventive actions, including reinspection and retest requirements, are recorded on the MRB document prior to disposition;

3) Perform trend analysis of discrepancies;

4) Ensure that MRB records are maintained.

c. Dispositions - In addition to the dispositions listed in 9.9.1.2, the MRB shall have authority for the following:

1) Repair - The MRB shall approve repairs, except as noted below. Standard Repair Procedures shall be submitted to NASA in accordance with the CDRL herein. The MRB shall authorize the use of the procedures for each instance of repair. The MRB shall ensure that the hardware reliability and quality are not compromised by excessive repairs;

2) Scrap;

3) Use-as-is. (Except as stated below. Also, see NOTE).

MRB disposition shall not adversely affect the safety, reliability, durability, performance, interchangeability, weight, or other basic features of the hardware.

NOTE: The products shall be withheld from further processing in a controlled area until the COTR gives direction for disposition.

9.9.2 CONTROL, REPORTING, AND DISPOSITION OF FAILURES

9.9.2.1 Failure Reporting.

A nonconformance report shall be written for each departure from design, performance, testing, or handling requirements that affects the function of the instrument or flight support equipment or could possibly compromise mission objectives. This includes test equipment (GSE) that interfaces with the flight or flight-support equipment. Other problems or anomalies that are unusual or that might affect other areas shall also be cited on a nonconformance report.

Reporting of hardware failures shall begin with the first power application at the lowest level of assembly or the first operation of a mechanical item; it shall continue through formal acceptance by the NASA project office and the post-launch operations, as required by the contract. For software problems, operation of this nonconformance system shall begin with the first test use of the software item with a hardware item of the mission system at the component level or higher.

9.9.2.2 Report Processing.

A nonconformance report shall be initiated immediately after a failure or anomaly has occurred. The reports shall be submitted to NASA in accordance with the CDRL and the identical information shall be submitted to the in-plant Government quality representative. The nonconformance report data shall be submitted in hard copy and electronically.

The hard copy submittals shall be made as the updating actions occur on each nonconformance report, and the iteration submitted to NASA for closure shall include a copy of all referenced data and shall have had all corrective actions accomplished and verified.

The submittal of the data in the above specified computer readable form shall be in monthly composite updates of all currently open nonconformance reports (with each data item separately identified to its respective nonconformance). When each nonconformance report is closed, the next monthly computer composite shall carry the closure update of all data on that nonconformance report.

The developer shall maintain a master report file that contains all supplementary data such as failure analysis and records of meetings.

9.9.2.3 Failure Review Board.

A Failure Review Board (FRB) shall be established and, as a minimum, shall comprise the following:

a. Developer quality or reliability representative (chairman);

b. Developer systems engineer or his representative;

c. Developer engineering representative responsible for the failed item;

d. NASA/GSFC COTR or his designee.

The developer shall select members on the basis of technical competence. The Government representative on the board shall approve the membership.

The FRB shall obtain the assistance of appropriate groups and personnel to ensure that all failures are investigated, analyzed, and their causes determined. Failures involving EEE parts shall be coordinated with the PCB. Investigations and actions shall be coordinated with NASA and documented on a nonconformance report. Trend analysis shall be performed and corrective action taken. Where it is determined that the affected item is discrepant, the FRB shall refer it to the MRB for disposition. Closeout of each failure shall require verification that remedial and preventive actions have been accomplished in the item on which the failure occurred, that necessary preventive design changes in the item have been accomplished and verified in test, and that effectivity of preventive actions has been established in other affected items. The FRB chairman, denoting approval of the entire Board, shall sign the nonconformance report closeout before submitting it to NASA in accordance with the CDRL. Nonconformance reports shall not be considered closed until signed by the authorized Government representative.

9. 10 ALERT INFORMATION

The developer shall review Alerts and SAFE-Alerts that document problems with parts, materials, processes, and safety as reported through the Government-Industry Data Exchange Program (GIDEP). Also, NASA may provide the developer other special notices of general problems. The developer shall notify NASA of any Alerts or problem notices, which have or may have an effect on the contract hardware. In accordance with the CDRL herein, the developer shall submit responses to these Alerts and problem notices, which inform NASA of the applicability of the problem to project hardware and any follow-up action proposed. The developer shall also respond to any specific NASA inquiry on the applicability of any part or materials problem to the contract hardware. The developer shall prepare Alerts on problems that are within the scope of the Alert system and shall submit a copy of the Alert to NASA when submitting it to GIDEP.

9. 11 INSPECTIONS AND TESTS

The developer shall plan and conduct an inspection and test program which demonstrates that contract, drawing, and specification requirements are met. Inspections and tests shall be performed on products before they are installed in the next level of assembly. Inspection shall include a review of product records. Each inspection and test shall be traceable to the individual responsible. Quality assurance personnel shall approve all manufacturing documentation prior to its use.

9.11.1 PLANNING

The developer shall plan for inspections and tests and for a documentation system that substantiates their accomplishment. The planning function shall provide for:

a. Orderly and timely inspection and tests at the earliest opportunity and through all phases;

b. Coordination and sequencing of inspection and tests conducted at successive levels of assembly to ensure satisfactory articles and materials and to eliminate unnecessary testing;

c. Availability of handling equipment and calibrated inspection and test equipment;

d. Coordination of inspections and tests conducted by the designated Government Quality Representative;

e. A documented listing of those inspection procedures utilizing sampling plans, including the sampling rationale. This shall be maintained as a part of the inspection planning documentation and shall be available to NASA for review upon request.

9.11.2 INSPECTION AND IN-PROCESS TEST PROCEDURES

Inspection and in-process test activities shall be conducted in accordance with documented procedures physically located at the applicable inspection or test station. The degree of detail in the procedures shall be commensurate with the complexity of inspection or in-process test operations. Inspection procedures may be a part of the manufacturing control documentation. All procedures shall include, as applicable, the nomenclature of the article, characteristics to be inspected or tested, accept/reject criteria, and special consideration regarding measuring or test equipment, standards, safety, and environment.

9.11.3 INSPECTION ACTIVITY

As a minimum the inspections in the following paragraphs shall be performed.

9.11.3.1 In-Process Inspection.

This task shall be performed at all levels of assembly in accordance with the following requirements:

a. The configuration, drawing requirements, and workmanship shall be verified prior to the next step of fabrication or integration; characteristics

shall be verified that cannot be verified later without destructive disassembly;

b. In-process inspection shall be done in a clean environment in accordance with the Contamination Control Plan;

c. In-process inspection personnel shall be certified for the selected processes and inspections;

d. In-process verification below the component level shall include electrical interface tests of assemblies prior to being integrated into the next higher level of hardware.

9.11.3.2 Final Inspection.

This task shall be performed at all levels of assembly:

a. Configuration, workmanship, and test results shall be verified before installation or use with the next higher level of assembly;

b. Verify that all nonconformances have been processed and all open items have been transcribed into the next level of inspection or fabrication documents;

c. Final inspection shall be done in a clean environment in accordance with the Contamination Control Plan;

d. Final inspection personnel shall be certified for the selected processes and inspections.

9.11.3.3 End-Item Inspection.

This task shall be performed to:

a. Verify that configuration, test results, workmanship, and the Acceptance Data Package is in compliance with the contract;

b. Verify that NASA has authorized the delivery of the end-item with such open non-conformances and unresolved tasks that may exist.

9.11.3.4 Surveillance Inspection.

Stored and stocked parts, materials, and flight or spare hardware shall be periodically inspected and tested for proper storage environment and packaging to prevent deterioration or damage.

9.11.4 QA Activities During the Integration and Test Phase

Assurance personnel shall ensure that the subassemblies, assemblies, components, and contract end-items are integrated and tested in accordance with controlling documents. Articles undergoing test shall not be adjusted, modified, repaired, reworked, or replaced except as specified in established documents, or in accordance with MRB actions. The status, configuration, and integrity of the hardware shall be maintained and documented. Integration and test activities shall be conducted in a clean area in accordance with the Contamination Control Plan.

Assurance personnel shall provide surveillance of all tests; the extent shall be defined in QA and test documents by quality assurance management. As a minimum the activities in the following paragraphs shall be performed.

9.11.4.1 Verification.

Prior to testing, the assurance personnel shall verify:

a. The presence of approved inspection and test documents;

b. The identification of products;

c. The configuration of products;

d. That test equipment is within the calibration period for the duration of the test;

e. Test setup and test configuration.

9.11.4.2 Test Documentation.

During tests the assurance personnel shall:

a. Ensure that tests are conducted in accordance with approved specifications and procedures.

b. Ensure accurate and complete recording of data and results.

c. Document rework, repairs or modifications.

d. Document non-conformances.

9.11.4.3 Post Test Assurance Activity.

Subsequent to testing, the assurance personnel shall:

a. Ensure proper disposition of articles;

b. Verify that test results, reports, and nonconformance documents are accurate, complete, and traceable to the tested products.

9.11.5 RECORDS OF INSPECTIONS AND TESTS (COMPONENT LEVEL TO END-ITEM)

9.11.5.1 General Requirements.

The developer shall prepare and maintain records, including logs, of all inspections and tests to show that all operations have been performed, the objectives met, and the end-item fully verified.

9.11.5.2 Scope.

Records shall cover each component, subsystem, and system. As the hardware is integrated, records of lower-level assembly products shall be combined into those for the end-item as a means of compiling a continuous, chronological history of identified hardware, fabrication, assembly, inspection, and tests as well as other actions or data important to a complete assurance record, such as idle periods (storage), movement of the end-item, repairs, approvals, maintenance, configuration data, etc.

Assurance personnel shall verify that records are complete. The records shall be retained at the developer's facility for a minimum of five years after launch of the hardware or otherwise as prescribed by the contract.

9. 12 CONFIGURATION VERIFICATION

Assurance personnel are required to verify that the as-built product complies with the currently approved as-designed configuration listing and is in accordance with approved configuration documents as required by configuration control requirements. The configuration shall be maintained and controlled throughout the program.

Configuration verification is required as a part of all inspections. A nonconformance report shall be initiated for any deviations of inspected as-built hardware from the current approved configuration. Any configuration nonconformances that are not corrected shall be documented on a Deviation/Waiver request form and processed in accordance with approved configuration management procedures.

The as-designed configuration and updates, as well as the as-built configuration verification report, shall be provided in accordance with the contractual CM requirements and included in the Acceptance Data Package.

9. 13 METROLOGY

9.13.1 General Requirements

The developer shall establish and comply with a documented metrology system that ensures that measurement standards and equipment (including GSE) are selected and controlled to the degree necessary to meet drawing requirements and functional test requirements. The system shall be in accordance with provisions of ISO-10012-1.

9.13.2 Instruments Used for Measuring

Tools, gages, jigs, and fixtures, which measure dimensions, contours, or locations affecting quality characteristics shall be checked for accuracy prior to use. Also, test equipment and instruments (including GSE) used in functional test of the hardware shall be calibrated to standards appropriate to their test uses and shall be checked for accuracy in accordance with appropriate procedures prior to use. Checks and recalibrations shall be made at predetermined intervals to ensure continued accuracy.

9.13.3 Product Measurement Process

The sum of random and systematic errors in any article or material measurement process shall not exceed ten percent of the tolerance or material characteristics being measured. Where state-of-the-art or other considerations make this provision impossible or impracticable the developer shall maintain a list of exceptions, and they shall be available for review upon request.

9.13.4 Calibration Measurement Process

The sum of random and systematic errors in any calibration measurement process shall not exceed 25 percent of the tolerance of the parameter being measured. Where state-of-the-art or other considerations make this provision impossible or impracticable the developer shall maintain a list of those exceptions and they shall be available for review upon request.

9. 14 STAMP CONTROL SYSTEM

The developer shall establish and maintain a documented stamp control system, which provides the following:

a. Stamps, decals, seals, and paints which are applied to flight hardware shall comply with the criteria of 6.2.4 and shall show that products have undergone source and receiving inspection, in-process fabrication and inspection, end-item fabrication, inspection and storage, and shipment;

b. Stamps shall be traceable to the certified individual responsible for their use, and records shall be maintained to identify the individual. Fabrication (manufacturing) and inspection stamps shall be of different design;

c. Stamps shall be applied to records to indicate the fabrication or inspection status of the products.

9. 15 SAMPLING PLANS

Sampling plans may be used when inspections or tests are destructive, or when data, inherent characteristics, or the noncritical application of a product allows for a reduction in inspection or testing. Such plans shall not jeopardize quality, reliability, or design intent. ANSI/ASQC Z1.4 or comparable standard shall be used for establishing the sampling plan requirements. The sampling plan shall provide an average quality level that is appropriate to the reliability requirements of the project. Sampling plans shall be identified in the applicable inspection procedures, and a listing of those inspection procedures utilizing sampling plans, including the sampling rationale, shall be maintained as a part of the inspection planning documentation.

9. 16 TRAINING AND CERTIFICATION FOR MANUFACTURING AND INSPECTION PERSONNEL

The developer shall implement a training and certification program in accordance with the applicable workmanship standards specified herein.

9. 17 HANDLING, STORAGE, PRESERVATION, MARKING, LABELING PACKAGING, PACKING, AND SHIPPING

The developer shall prepare and implement procedures for the handling, storage, preservation, marking, labeling, packaging, packing, and shipping of all products. Procedures shall be submitted in accordance with the CDRL herein.

9.17.1 HANDLING

The protection of products during the life of the program shall be achieved through the use of handling equipment (including GSE) and techniques, which have been certified before, use. Evidence of initial and periodic proof testing of handling equipment shall be maintained.

9.17.2 STORING, PRESERVATION, MARKING, LABELING PACKAGING, AND PACKING

Products shall be stored, preserved, marked, labeled, packaged, and packed to prevent loss of marking, deterioration, contamination, or damage during all phases of the program. Stored and stocked items shall be controlled in accordance with documented procedures and be subject to quality surveillance.

9.17.3 SHIPPING

For instruments that are sensitive to damage from mechanical shock or extreme temperature exposure, monitoring devices shall be included at appropriate locations

within the shipping containers to provide evidence of any exposure to potentially damaging shipping stresses.

Prior to shipping, quality assurance personnel shall ensure that:

a. Fabrication, inspection, and test operations have been completed and accepted;

b. All products are identified and marked in accordance with requirements;

c. The accompanying documentation (developer's shipping and property accountable form) has been reviewed for completeness, identification, and quality approvals;

d. Evidence exists that preservation and packaging are in compliance with requirements;

e. Packaging and marking of products, as a minimum comply with applicable rules and regulations and are adequate to ensure safe arrival and ready identification at their destinations;

f. The loading and transporting methods are in compliance with those designated in the shipping documents;

g. Integrity seals are on shipping containers and externally observable shock or temperature monitors do not show excessive environmental exposure;

h. In the event of unscheduled removal of a product from its container, the extent of re-inspection and retest shall be as authorized by NASA or its representative;

i. Special handling instructions for receiving activities, including observation and recording requirements for shipping-environment monitors are provided where appropriate.

The developer's quality assurance organization shall verify prior to shipment that the above requirements have been met. QA shall sign off appropriate shipping documents to provide evidence of this verification.

9. 18 GOVERNMENT PROPERTY CONTROL

9.18.1 DEVELOPER'S RESPONSIBILITY

In accordance with the provisions of the contract, the developer shall be responsible for and account for all property supplied by the Government including Government property that may be in the possession or control of a supplier. The developer's responsibility shall include, but not be limited to, the following:

a. Upon receipt, examine products to detect damage that may have occurred in transit;

b. Inspection for quantity, completeness, proper type, size and grade as specified in the shipping documents;

c. Provision for the protection, maintenance, calibration, periodic inspection, segregation, and controls necessary to prevent damage or deterioration during handling, storage, installation, or shipment;

d. Maintenance of records which include:

(1) Identification of the property;

(2) Location of the property;

(3) Dates, types, and results of developer inspections, tests, and other significant events;

e. Any functional tests shall be performed on the product only if such tests are directed by the NASA project office;

9.18.2 UNSUITABLE GOVERNMENT PROPERTY

The property shall be processed in accordance with Government procedures. The property shall not be dispositioned, repaired, reworked, replaced, or in any way modified unless such action is authorized by the contract or by the Contracting Officer in writing.

9. 19 GOVERNMENT ACCEPTANCE

Prior to acceptance by NASA, quality assurance personnel shall ensure that deliverable contract end-items, including the Acceptance Data Package and Software Delivery Package, are in accordance with contract requirements. A copy of the data package shall be submitted to NASA in accordance with the CDRL.

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10.0 CONTAMINATION CONTROL REQUIREMENTS

10. 1 APPLICABILITY AND DEFINITIONS

A contamination control program shall be conducted to meet the needs of the ATMS instrument and the NPP Project. The contamination control allowances for the instrument developed under this program shall be used to establish the contamination control requirements for the integration, test, and mission use of the instrument when integrated with the spacecraft.

Contaminants are defined as those materials, either at a molecular or a particulate level, whose presence degrades mission performance. The source of these contaminants may be the Platform, the developer's instrument, other instruments in the payload, any material or equipment coming in contact with the instrument, the test facilities, and/or the environments to which the instrument is exposed.

10.1.1 INSTRUMENT CROSS-CONTAMINATION

The NPP spacecraft will accommodate several instruments with widely varying contamination sensitivities in close proximity. In order to minimize the chance of jeopardizing instrument performance due to cross-contamination, each instrument, regardless of its contamination sensitivity, shall meet the minimum cleanliness requirements established in the SRD "Common Section".

10. 2 CONTAMINATION CONTROL PLAN

The developer shall prepare and implement a Contamination Control Plan (CCP) that includes contamination allowances, methods for control, and verifications that the allowances have been met. At least one copy of all referenced analyses, procedures, standards, and specifications, with the exception of Government standards, shall be provided with the CCP. The plan shall be submitted in accordance with the CDRL herein.

10.2.1 CONTAMINATION ALLOWANCES

As a basis for contamination control activities, the developer shall establish contamination allowances for performance degradation of contamination-sensitive hardware such that even when degraded by contamination within the stated allowance, the hardware will meet its mission objectives. The contamination allowances for the developer's instrument shall reflect the allowable contamination levels defined in the SRD "Common Section". The following information related to contamination allowances shall be included in the CCP:

a. The sensitivity of the instrument to contamination, the contamination control concerns, and potential sources of contamination;

b. The science requirements and allowable performance degradation;

c. Contamination allowances for all sensitive surfaces. Allowable outgassing and particulate contamination levels shall also be defined for materials or subsystems near contamination-sensitive surfaces. All analyses performed to assess instrument sensitivity and to derive contamination allowances shall be documented.

10.2.2 CONTAMINATION CONTROL

The developer shall prescribe in the CCP the measures to be taken to ensure that the established contamination allowances are not exceeded. This shall include a description of the facilities, and a description of all procedures used after fabrication and during integration and test, interfacing with other subsystems or the Observatory, cleaning, bagging, transportation, etc. An operations flow chart shall be included.

10.2.3 VERIFICATION

The developer shall detail in the CCP the methods of verification (e.g. measurements, inspections, tests, and analyses) to be used during each phase of the hardware lifetime. For each method, the documented procedure and data recording requirements shall be enumerated or referenced. The CCP shall include criteria for defining out-of-control conditions and planned methods of dealing with them.

10.2.4 HARDWARE HANDLING

The developer shall practice cleanroom standards in handling hardware. The contamination potential of material and equipment used in cleaning, handling, packaging, tent enclosures, shipping containers, bagging (e.g., anti-static film materials), and purging shall be addressed in the CCP.

10. 3 MATERIAL OUTGASSING

All materials will be screened in accordance with NASA Reference Publication 1124, Outgassing Data for Selecting Spacecraft Materials. Individual material outgassing data will be established based on hardware's operating conditions and reviewed by GSFC. It is required that the total amount of outgassed condensable volatile matter from the instrument stay within the outgassing and particulate contamination allowances, even though the construction materials used satisfy the unit outgassing criteria for TML and CVCM prescribed in the SRD "Common Section".

Instruments shall be designed so that gases vented during ascent and on-orbit will be directed away from contamination sensitive surfaces or areas of the developer's instrument and adjacent instruments.

10.3.1 BAKE-OUTS

The developer will perform thermal vacuum bake-outs of all hardware. The parameters of such bake-outs (e.g., temperature, duration, pressure) must be individualized depending on materials used, the fabrication environment, and the established contamination allowance. During these bake-outs the outgassing shall be measured to ensure compliance with established allowances. The parameters (e.g. verification method, temperature, duration, pressure) of such bake-outs shall be individualized, depending on the materials used, the fabrication environment, and the established contamination allowance. The bake-out parameters for each hardware item shall be documented in individual bake-out specifications and referenced in the CCP.

10.3.2 THERMAL VACUUM TEST

The CCP shall include or reference the contamination controls to be exercised in preparing the thermal-vacuum chamber and the necessary fixtures and stimuli for system level tests. These shall include the operational procedures that will be followed to minimize the potential contamination hazard, from pumpdown through return to ambient conditions. Test phases that represent contamination hazards and the approaches to be taken to minimize these hazards shall be addressed. Pretest measurements, monitoring methods to be used during the test, and post-test measurements for verifying that contamination criteria have not been exceeded shall be prescribed. Contingency plans dealing with the possibility that contamination criteria are exceeded shall be included.

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11.0 SOFTWARE ASSURANCE REQUIREMENTS

11. 1 GENERAL

The developer shall have a Software Quality Management System (SQMS) that is compliant with ANSI/ASQC Q9001. The SQMS shall be applied to all software developed under this contract.

The developer's Quality Manual shall be provided in accordance with the RFP or CDRL. The developer shall allow NASA audits to assure compliance of the developer's SQMS with ANSI/ASQC Q9001 and to assure that the SQMS is applied to the contracted software activities.

11. 2 QUALITY SYSTEM AUGMENTATIONS

The developer's compliant SQMS shall be augmented as shown in the following numbered sections. References are to paragraphs in ISO/FDIS 9000-3:1997(E), which provides guidance on the development of a SQMS that is compliant with the ANSI/ASQC Q9001.

11.2.1 AUGMENTATION TO PARAGRAPH 4.1.3, ANSI/ASQC Q9000-3, JOINT REVIEWS

There shall be a series of formal reviews with developer presentations of the review material. The reviews shall be conducted by GSFC with a review panel that will include independent experts in software of the type being reviewed. The formal reviews shall consist of, as a minimum, a Software Requirements Review (SRR), a Critical Design Review (CDR), a Delta Critical Design Review (ΔCDR), a Test Readiness Review (TRR), and an Acceptance Review (AR). These reviews shall be coordinated with the reviews defined in Section 3. The developer shall record minutes of and action items identified during the review.

11.2.2 AUGMENTATION TO PARAGRAPH 4.1, ANSI/ASQC Q9000-3, CORRECTIVE ACTION

The corrective action process shall start at the establishment of a Configuration Management baseline that includes the product. In no case shall the use of the formal software corrective action process be delayed beyond the first instance of the software being delivered to test in order to verify software requirements.

The GSFC shall be allowed access to software problem reports and the corrective action information as they are developed.

11.2.3 AUGMENTATION TO PARAGRAPH 4.8, ANSI/ASQC Q9000-3, CONFIGURATION MANAGEMENT

The developer shall establish a Software Configuration Management (SCM) baseline after each formal software review defined in 11.2.1. Software products shall be placed

under Configuration Management immediately after the successful conclusion of the review. Informal control shall be used on preliminary versions of all products before being placed under control in the formal SCM system.

The developer's SCM system shall have a change classification and impact assessment process that results in Class 1 changes being forwarded to GSFC for disposition. Class 1 changes are defined as those, which affect system requirements, software requirements, system safety, reliability, cost, schedule, and external interfaces.

11.2.4 AUGMENTATION TO PARAGRAPH 4.10.4, ANSI/ASQC Q9000-3, INSPECTION AND TESTING

11.2.4.1 Software Test Procedures

The developer shall prepare and submit software test procedures in accordance with the CDRL.

11.2.4.2 Software Test Reports

The developer shall prepare software test reports that summarize each of the software acceptance test or retest activities. The report shall show which of the planned tests were completed, conformance of the test results to the expected results, the number, type and criticality of the discrepancies found, the identification of components tested, and an analysis of any performance requirements that the items tested could affect. The reports shall be submitted in accordance with the CDRL.

11.2.5 AUGMENTATION TO PARAGRAPH 4.10.4, ANSI/ASOC Q9000-3, FINAL INSPECTION AND TESTING

The developer shall conduct a Functional Configuration Audit (FCA) and Physical Configuration Audit (PCA) on the final delivered product and on major upgrades (defined as the change of 20% or more of the lines of code) to that product. The developer shall provide the results of the audit to GSFC.

11.2.6 AUGMENTATION TO PARAGRAPH 4.20, ANSI/ASOC Q9000-3, STATISTICAL TECHNIQUES

The developer shall provide, from the developer defined set of software metrics, reports to GSFC that provide insight into the quality of the developer's software development processes and software products.

11. 3 GFE, EXISTING AND PURCHASED SOFTWARE

If the developer will be provided software as government-furnished equipment (GFE), or will use existing or purchased software, the developer is responsible for the software meeting the functional, performance, and interface requirements placed upon it. The developer is responsible for ensuring that the software meets all applicable standards,

including those for design, code, and documentation, or for securing a GSFC project waiver to those standards. Any significant modification to any piece of the existing software shall be subject to all of the provisions of the developer's SQMS and the provisions of this document. A significant modification is defined as the change of twenty percent of the lines of code in the software.

11.3.1 FIRMWARE

Developed firmware shall be subject to the same requirements as developed software. Purchased firmware shall be subject to the same requirements as purchased software.

11. 4 SOFTWARE SAFETY

If any software component is identified as safety critical, the developer shall conduct a software safety program on that component that complies with NASA-STD-8719.13A "NASA Software Safety Standard".

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12.0 RISK MANAGEMENT REQUIREMENTS

Risk Management applies to all software and hardware products and processes (flight and ground) in order to identify, analyze, plan mitigation actions, track, and control risks. Although not all risks will be fully mitigated, all risks shall be addressed and mitigation and acceptance strategies shall be agreed on at appropriate mission reviews.

The developer shall:

a. Search for, locate, identify, and document reliability and quality risks before they become problems;

b. Evaluate, classify, and prioritize all identified reliability and quality risks;

c. Develop and implement risk mitigation strategies, actions, and tasks and assign appropriate resources;

d. Track risks being mitigated: capture risk attributes and mitigation information by collecting data, establishing performance metrics, and examining trends, deviations, and anomalies;

e. Control risks by deciding to perform risk closeout, re-planning, contingency planning, or continued tracking and execution of the current plan;

f. Communicate and document to assure risk information is conveyed between all levels of the project (Risk recording, reporting and monitoring system).

Risk information shall be reported to the project via the weekly and monthly status reports.

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13.0 APPLICABLE DOCUMENTS LIST

DOCUMENT NUMBER	DOCUMENT TITLE	MAR REFERENCE
N/A	Sensor Requirements Document	1.7
EWR 127-1	Eastern and Western Test Range Safety Requirements	2.1, 7.2.2
NASA-STD-6001	Flammability, Odor, Off-gassing and Compatibility Requirements & Test Procedures for Materials in Environments That Support Combustion	7.2.2
GSFC S-311-98	Guidelines for Conducting a Packaging Review	3.5
NASA-STD-8739.3	Soldered Electrical Connections	5.2
NASA-STD-8739.4	Crimping, Interconnecting Cables, Harnesses and Wiring	5.2
NASA-STD-8739.1	Workmanship Standard for Staking and Conformal Coating of Printed Wiring Boards and Electronic Assemblies	5.2
NHB 5300.4 (3M)	Requirements for Surface Mount	5.2
NASA-STD-8739.7	Electrostatic Discharge Control (Excluding Electrically Initiated Explosive Devices)	5.2, 9.8
IPC-2221	Generic Standard on Printed Board Design	5.2
IPC-2222	Sectional Design Standard for Rigid Organic Printed Boards	5.2
IPC-RB-6011 & 6012	Qualification/Performance Specification for Rigid Printed Wiring Boards	5.2
GSFC Supplement S-312-P003	Process Specification for rigid Printed Wiring Boards for Space Applications and Other High Reliability Uses	5.2
GSFC 311-INST-001 Revision A	Instructions for EEE Parts Selection, Screening and Qualification	6.2.2

PPL-21	Goddard Space flight Center Preferred Parts List	6.2.3
S-311-M-70	Destructive Physical Analysis	6.2.6
MSFC-SPEC-522	Design Criteria for Controlling Stress Corrosion Cracking	7.2.1
GSFC S-313-100	GSFC Fastener Integrity Requirements	7.2.6.1, 9.5.8
ANSI/ASQC Q9001-1994	Model for Quality Assurance in Design, Development, Production, Installation, and Servicing	9.1
NASA-STD-5006	General Fusion Welding Requirements for Aerospace Materials Used in Flight Hardware	9.5.8, 9.5.13
ISO 10012-1 Part I	Metrological Confirmation System for Measuring Equipment	9.13.1
ANSI/ASQC Z1.4	Sampling Procedures and Tables for Inspection by Attributes	9.15
NASA Reference Publication 1124	Outgassing Data for Selecting Spacecraft Materials	10.3
ISO/FDIS 9000-3:1997(E)	Guidelines for Applying the ISO 9001 Standard to Software	11.2
NASA-STD-8719.13A	NASA Software Safety Standard	11.4

14.0 ACRONYMS

ABPML	As-Built Parts and Materials List
ANSI	American National Standards Institute
AR	Acceptance Review
ASQ	American Society for Quality
ASIC	Application Specific Integrated Circuits
ATMS	Advanced Technology Microwave Sounder
BOL	Beginning of Life
CCP	Contamination Control Plan
CDR	Critical Design Review
CDRL	Contract Delivery Requirements List
CIL	Critical Items List
COTR	Contracting Officer's Technical Representative
CSRD	Common Section of the Sensor Requirements Documet
CPT	Comprehensive Performance Test
CVCM	Collected Volatile Condensable Mass
DID	Data Item Description
ΔCDR	Delta Critical Design Review
DOD	Department of Defense
DPA	Destructive Physical Analysis
EDU	Engineering Development Unit
EEE	Electrical, Electronic, and Electromechanical
ELV	Expendable Launch Vehicle
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
EOL	End of Life
FATFP	Fabrication, Assembly and Test Flow Plan
FMEA	Failure Modes and Effects Analysis
GFE	Government-Furnished Equipment
GIA	Government Inspection Agency
GIDEP	Government Industry Data Exchange Program
GSE	Ground Support Equipment
GSFC	Goddard Space Flight Center
GSI	Government Source Inspection
IAC	Independent Assurance Contractor
ICD	Interface Control Document
LPT	Limited Performance Test
LRR	Launch Readiness Review
MCM	Multi-Chip Module
MIL	Materials Identification List
MSFC	Marshall Space Flight Center
MSPSP	Missile System Pre-launch Safety Package
MUA	Materials Usage Agreement
NASA	National Aeronautics and Space Administration
NDE	Nondestructive Evaluation

NHB	NASA Handbook
NPP	NPOESS Preparatory Project
OHA	Operations Hazard Analysis
OSSMA	Office of Systems Safety and Mission Assurance
PCB	Parts Control Board
PCP	Parts Control Plan
PER	Pre-Environmental Review
PIL	Parts Identification List
PPL	Preferred Parts List
PSR	Pre-Shipment Review
PWB	Printed Wiring Board
QA	Quality Assurance
QCM	Quartz Crystal Microbalance
RFP	Request for Proposal
RH	Relative Humidity
SCC	Stress Corrosion Cracking
SCD	Source Control Drawing
SCM	Software Configuration Management
SOW	Statement of Work
SQMS	Software Quality Management System
SRD	Sensor Requirements Document
SRO	Systems Review Office
SRR	Software Requirements Review
SSPP	System Safety Program Plan
TML	Total Mass Loss
TRR	Test Readiness Review
WR	Western Range